CPTEC
Centro de Previsão de Tempo e Estudos Climáticos

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Numerical Simulation of the South American Monsoon System (SAMS) by CPTEC Climate AGCM

Silvio Nilo Figueroa (CPTEC/INPE)
Henrique M.J. Barbosa (USP)
Pedro Silva Dias (LNCC)
José Paulo Bonatti (CPTEC/INPE)

colaborators: G. Grell, A.Betts, M. A. Silva Dias, E. Souza, S. Frietas, P. Kubota, R. Santos.

AGU Meeting of the Americas, 8-12 August 2010, Foz de Iguaçu-Brazil

WWW.CPTEC.INPE.BR

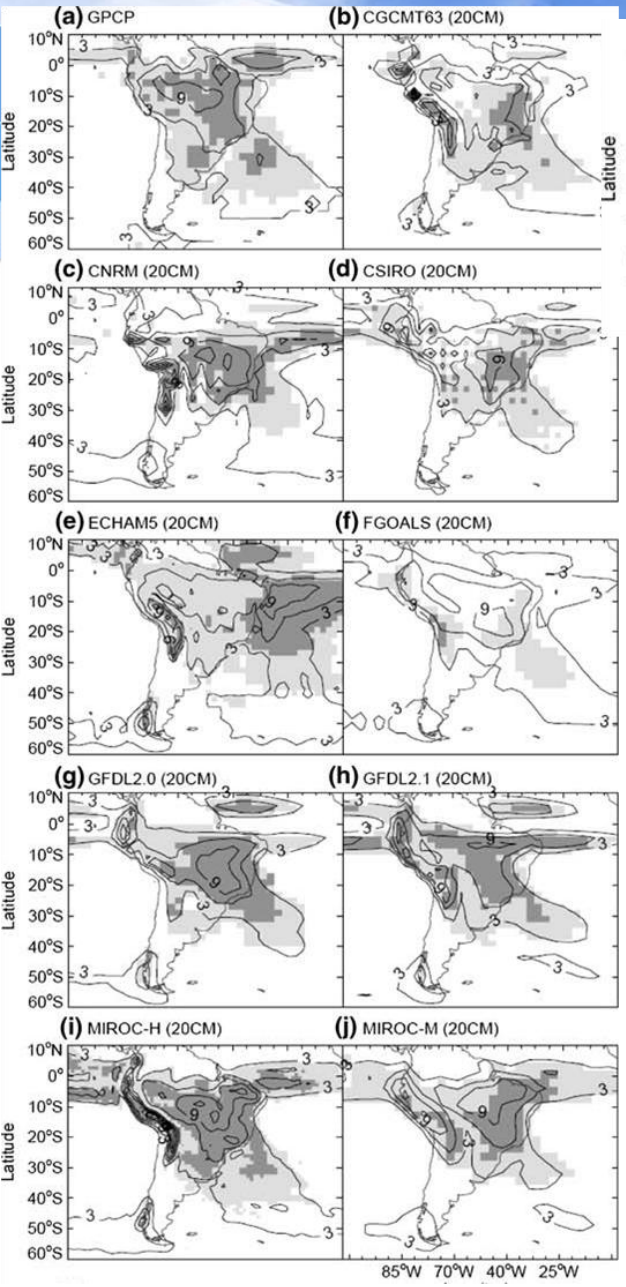
Outline

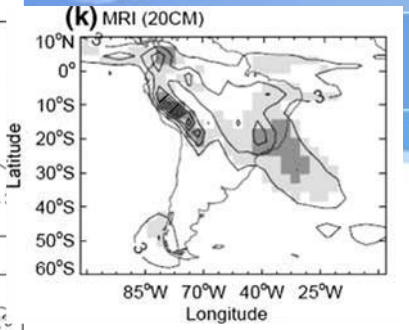
- Motivation
- Objectives
- Observed diurnal cycle of precipitation
- CPTEC-Shallow cumulus scheme
- Testing the new model (1D) for BOMEX case
- Simulation for transition period (Spring2002)
- Simulation of summer SAMS 2005-2006
- Long simulation of the SAMS, 1981-2009 (29 years)
- Conclusions

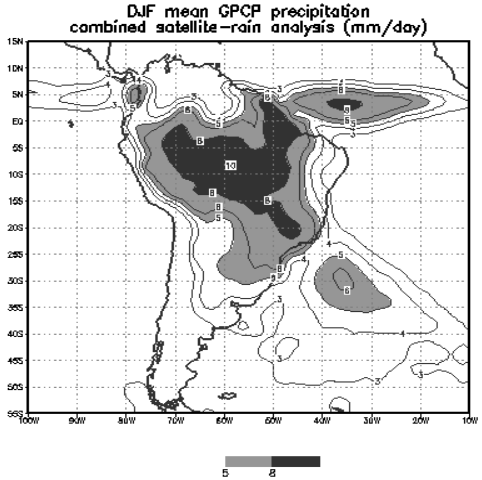
MOTIVATION

How reliable are predictions of future climate, if the model is not able to simulate de present climate?

- General Circulations Models (GCMs) have proven to be extremely important tools for understanding the present and past climate, seasonal climate prediction and projections of global climate change.
- The model must simulate the current climate state for confidence the future climate predictions.
- The ability of the models to reproduce the current climate builds confidence in their physical validity.
- Although both GCMs coupled atmosphere-ocean and Atmospheric GCMs (AGCMs) with sea temperature (SST) prescript reproduce the large scale features, but most of them, including CPTEC-AGCM fail to simulate clouds and precipitation over Tropical South America realistically.
- In particular the Amazon Convection is poorly simulated. This poor simulation of major center of convection and heat latent source over tropical land is one of the serious limitations not only for future climate prediction, but also for simulations to understand the present and past climate over South America.







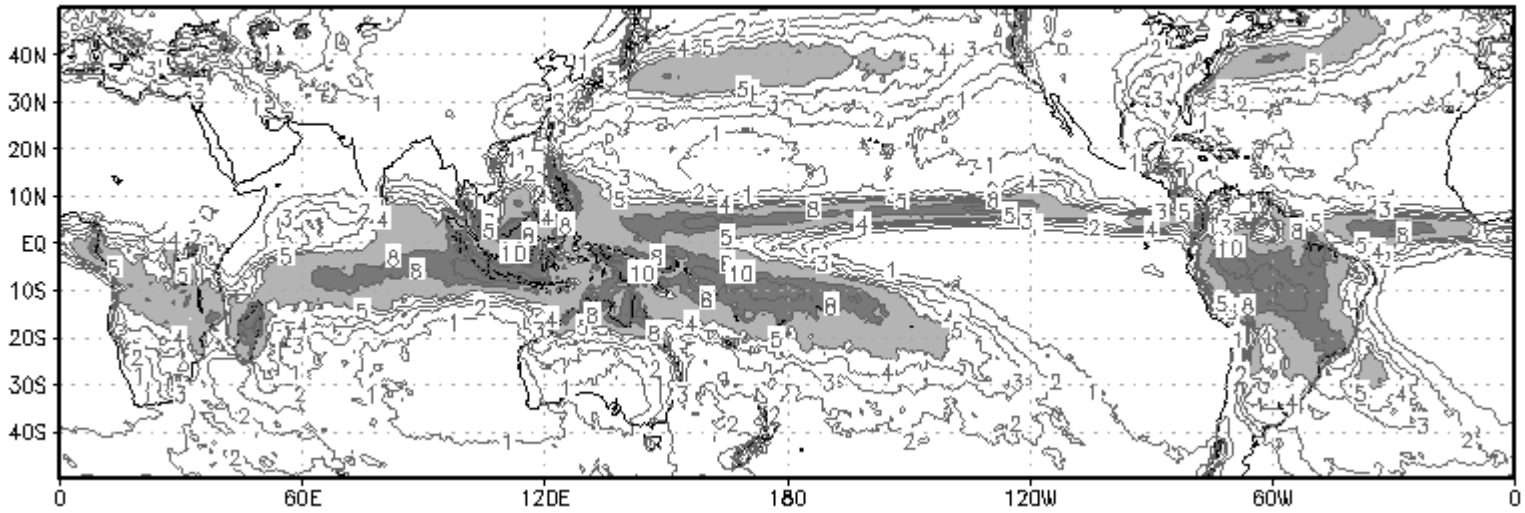
1-Amazon Convection is poorly simulated

2- Intense precipitation over Nordeste

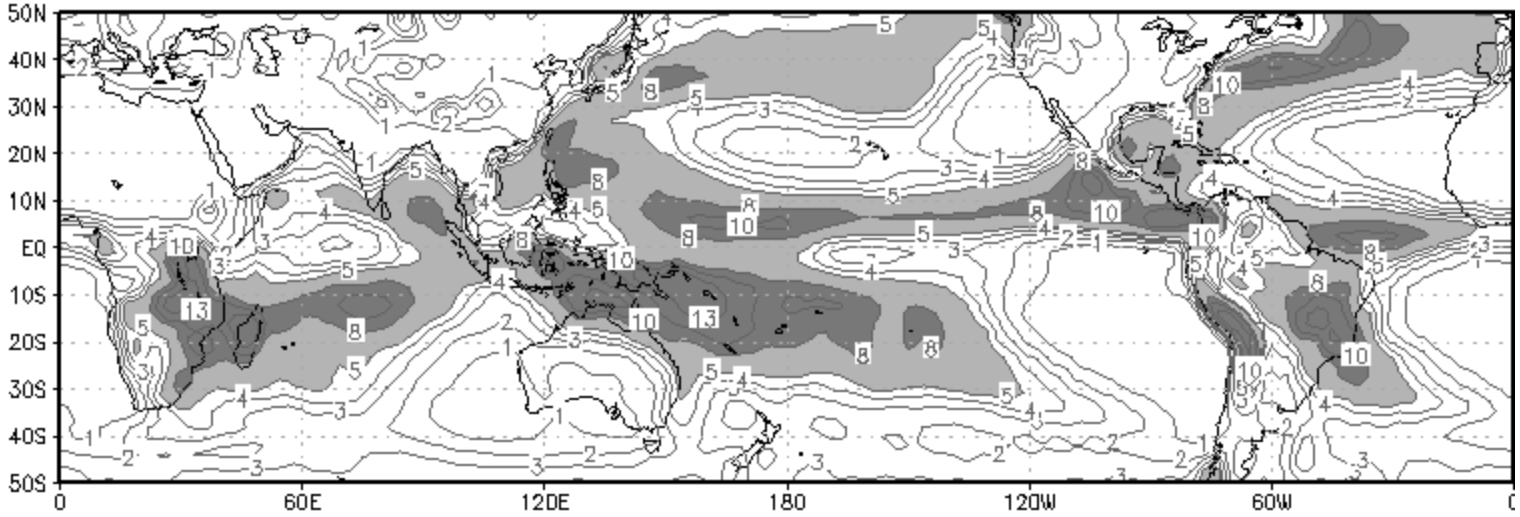
3. Atlantic ITCZ is poorly simulated

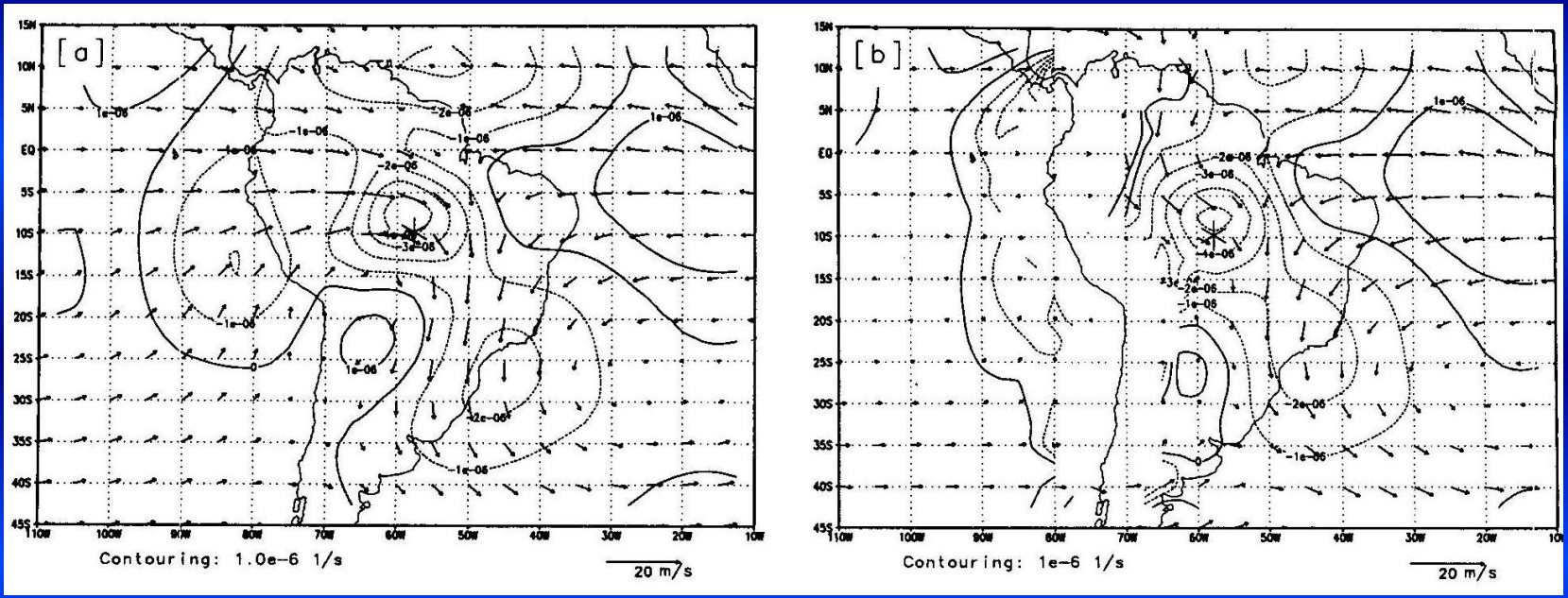
Bombardi and Carvalho (2009)

TRMM - 1998-2009



AGCM1-CPTEC - 1998-2009

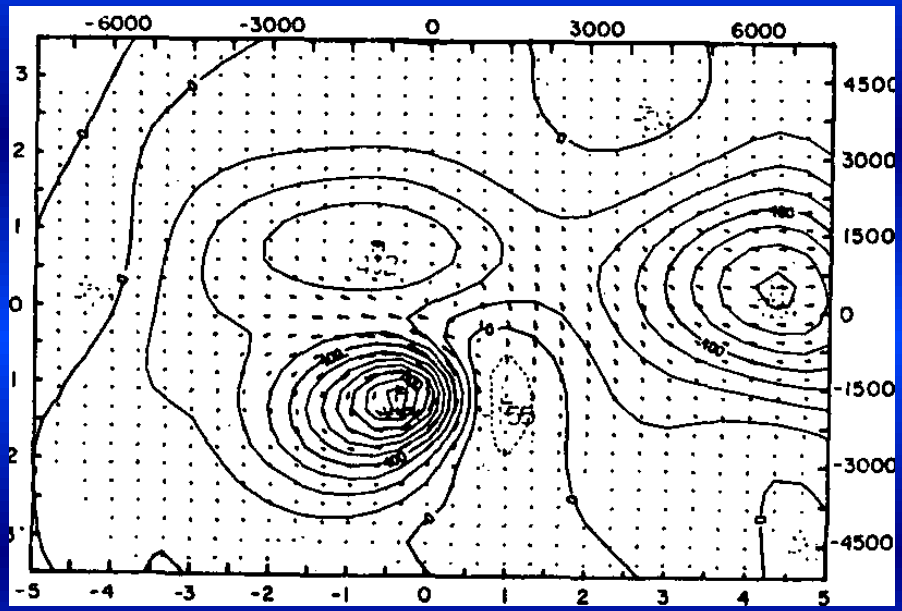




ORIGIN OF THE SACZ
Vector wind and divergence at 850 hPa (Figueroa et al. 1995)

The numerical simulation of the SACZ
1) Amazon Convection
2) Diurnal cycle of convection

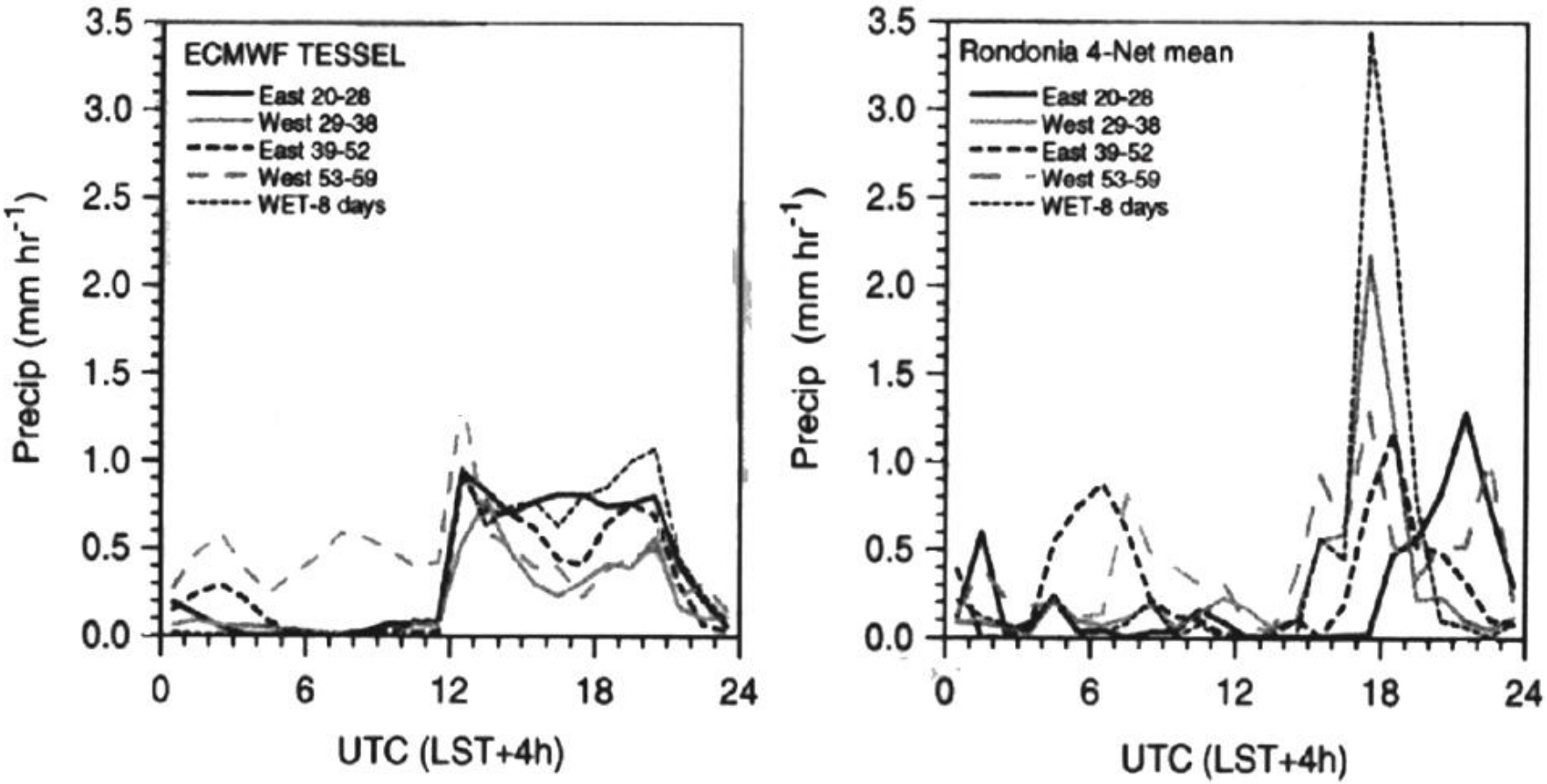
The numerical simulation of the Bolivian High (BH)
1) Amazon Convection
2) SACZ



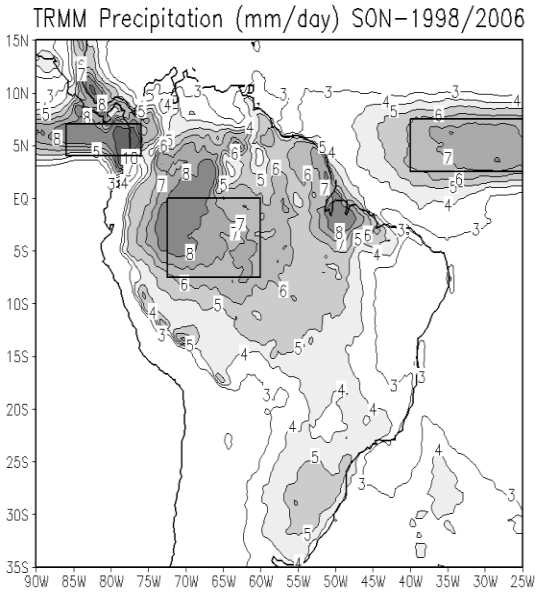
Silva Dias et al. (1983)

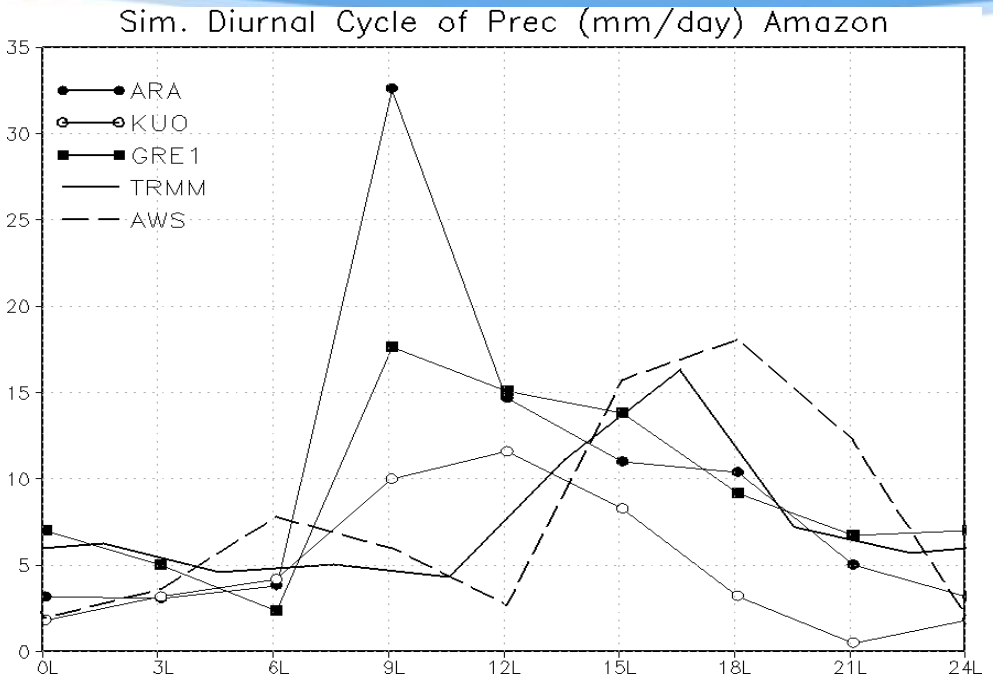
DIURNAL CYCLE OF PRECIPITATION OVER LAND

- Over the continents where the diurnal forcing is dominant (eg. Amazon), deep precipitation typically occurs at late afternoons.
- However, in most global models the convective triggering somehow delays by another few hours
- Similar to other AGCMs, the current CPTEC-AGCM have deficiencies in simulating the diurnal cycle of clouds and precipitation.
- Examples:



Diurnal cycle of precipitation over Rondonia. From Betts and Jakob (2002).





An accurate representation of the amplitude and phase of the diurnal cycle provides a key test of many aspects of the physical parameterizations in an atmospheric model.

The transition from shallow to deep convection in the diurnal cycle over land is a complex process.

- Over the continents where the diurnal forcing is dominant (eg Amazon), deep precipitation typically occurs at late afternoons.
- However, in most global models the convective triggering somehow delays by another few hours, because the models are not able to simulate the transition from shallow to deep convection.

Objective

- To Improve the deep convection Grell ensemble mass-flux parameterization approach
- To develop a new shallow convection scheme based on a mass-flux parameterization approach
- To understand the physical processes associated the new scheme focusing on the relation between shallow convection and diurnal cycle of deep convection and heating profile
- To evaluate the model in long integrations:the annual cycle, intra-seasonal variability, inter-annual variability and decadal variability

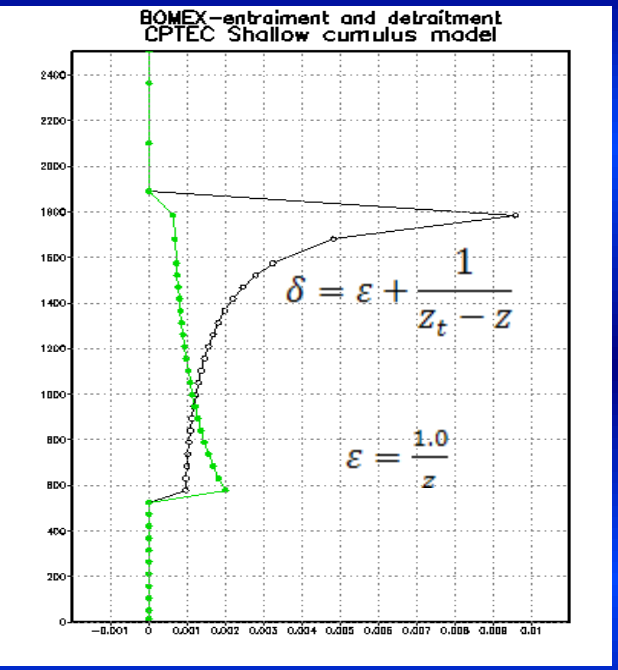
Shallow cumulus convection plays an important role in tropical climate dynamics, in which convective mixing between the atmospheric boundary layer and the free troposphere initiates a chain of large-scale feedbacks.

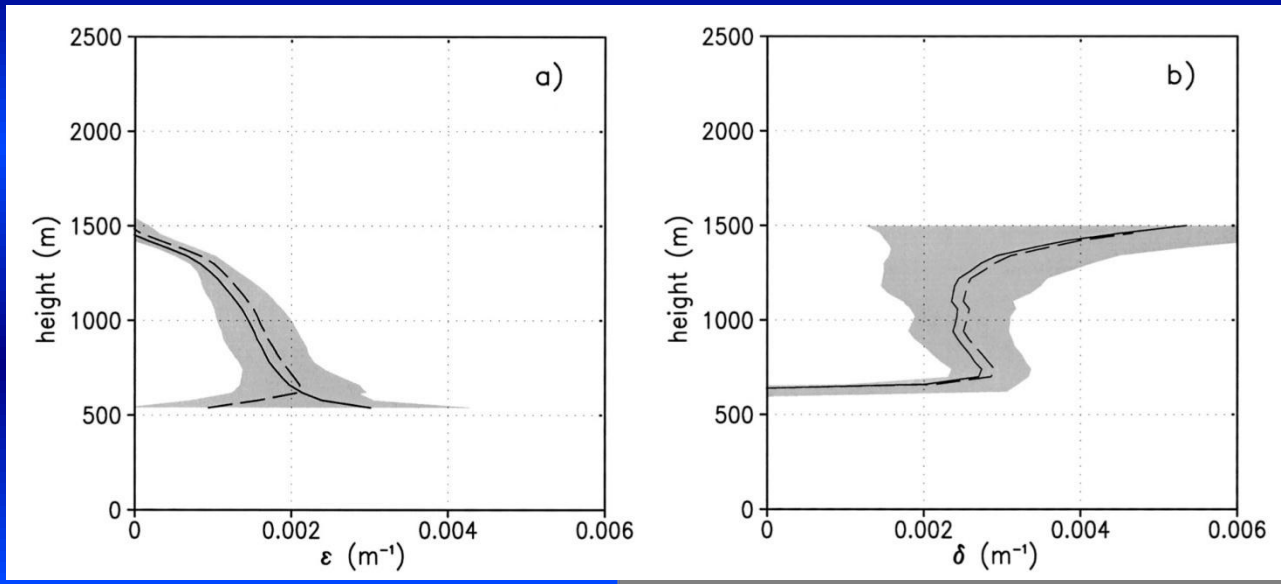
$$\varrho \frac{\partial a\chi_c}{\partial t} = -\frac{\partial (M_c \chi_c)}{\partial z} + E\chi_e - D\chi_c - \frac{\partial a\varrho(z)\overline{w'\chi'}^{c}}{\partial z}$$

$$-\varrho \frac{\partial (1-a)\chi_e}{\partial t} = -\frac{\partial (M_c \chi_e)}{\partial z} - E\chi_e + D\chi_c - \frac{\partial (1-a)\varrho(z)\overline{w'\chi'}^{e}}{\partial z}$$

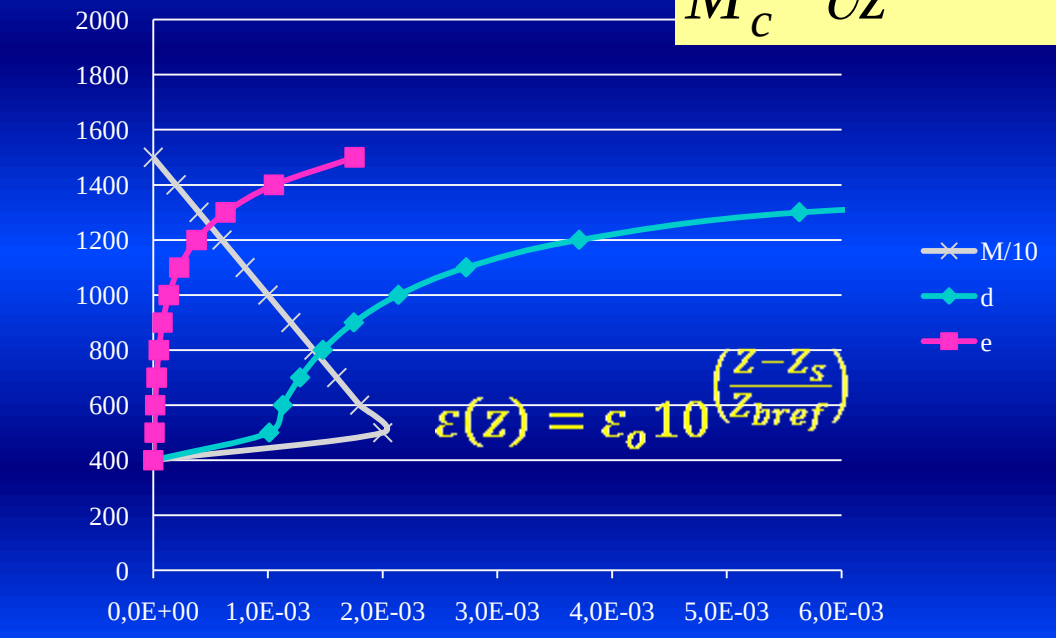
$$\varrho \frac{\partial a}{\partial t} = -\frac{\partial M_c}{\partial z} + E - D$$

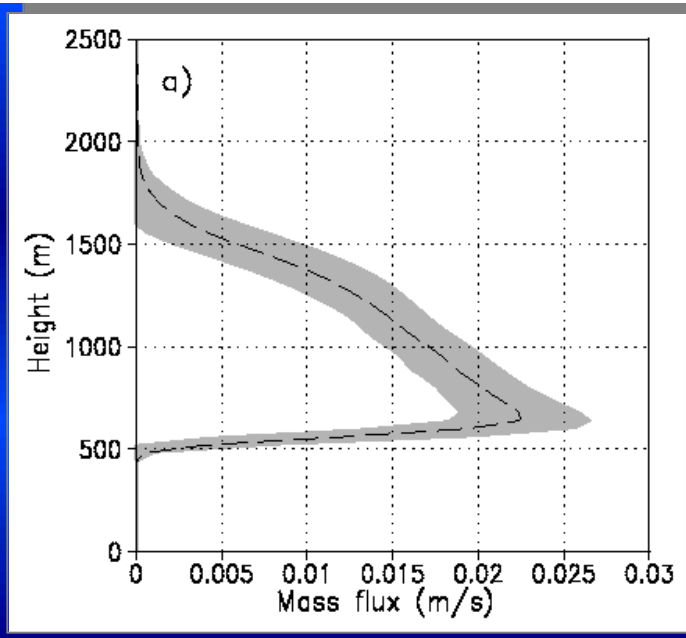
$$\chi \epsilon \{s_l, q_t\}$$





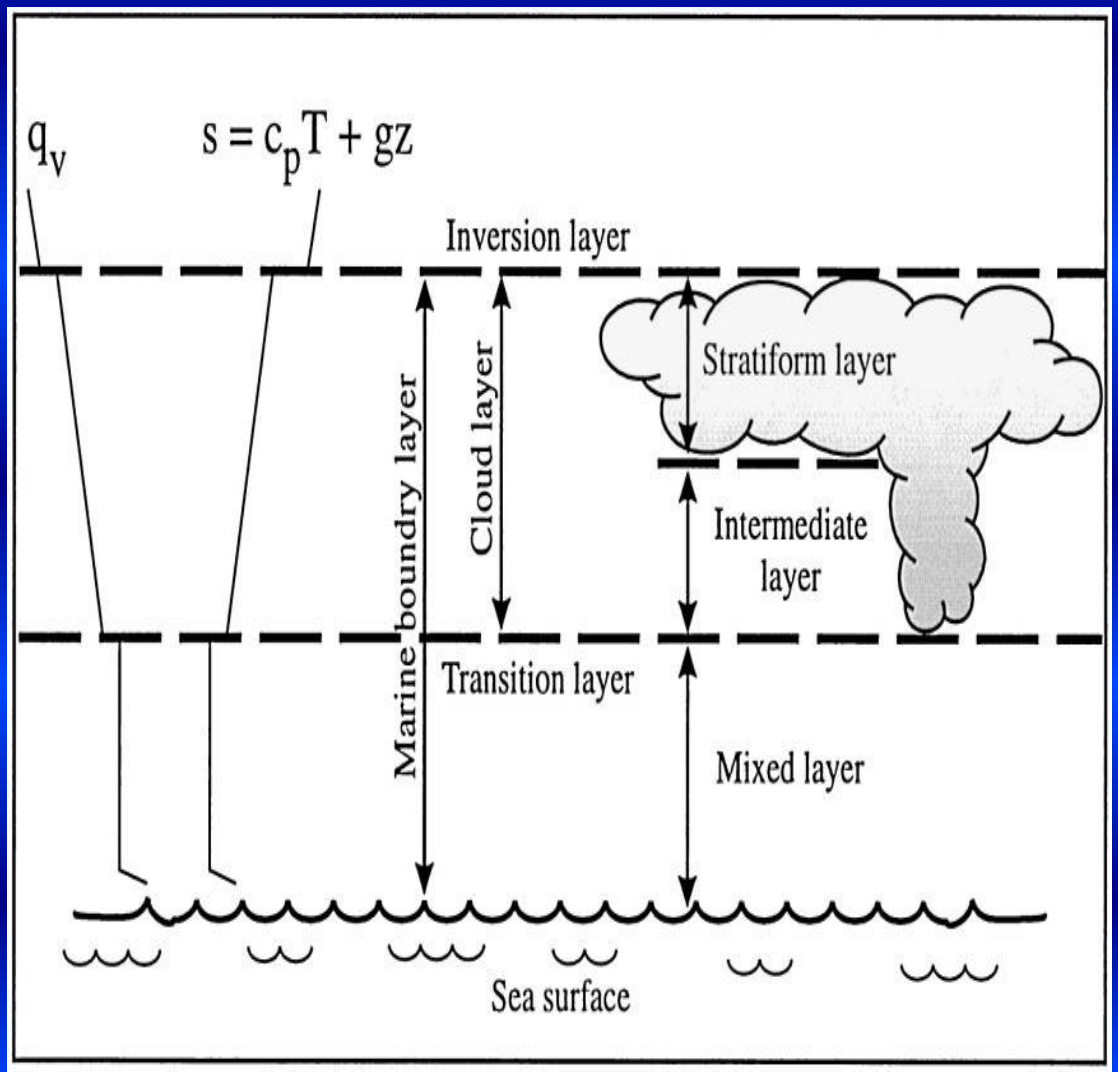
$$\frac{1}{M_c}\frac{\partial M_c}{\partial z} = \varepsilon - \delta$$

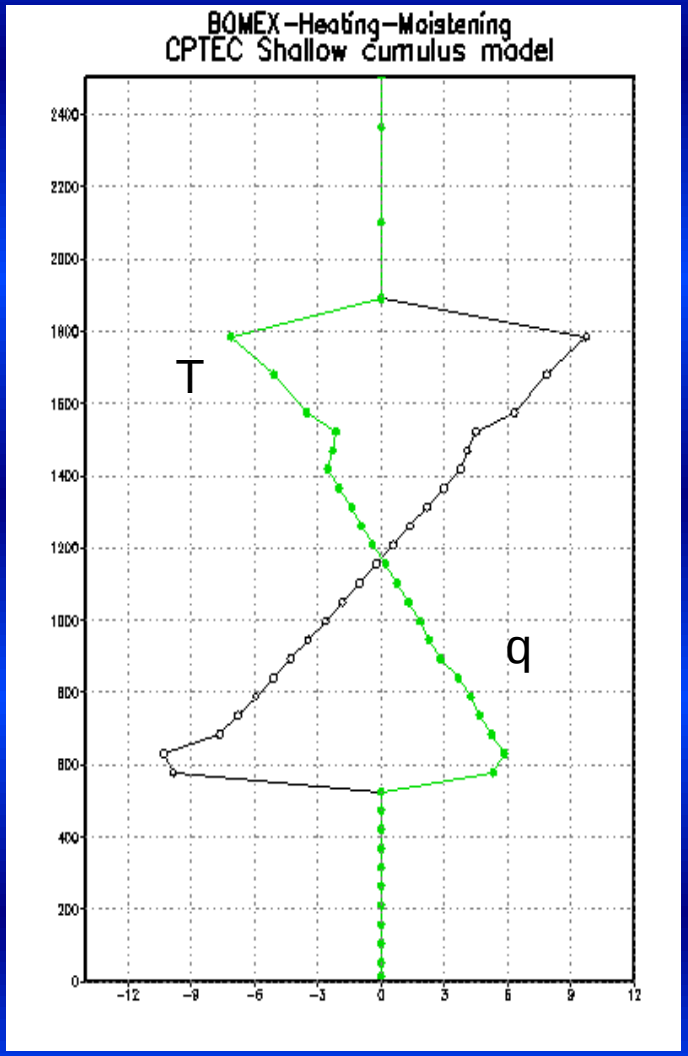




Large-eddy simulations (LES). Siebesma et al , (2003)

TESTING THE MODEL FOR BOMEX CASE





SIMULATIONS: SUMMER SAMS 2005-2006

- The South American Monsoon System (SAMS) is simulated by the CPTEC climate AGCM.
- The new atmospheric model includes new convective parameterization schemes (deep and shallow).
- The model with triangular truncation T63 and 28 levels and for 5 different initial conditions has been run from September 2005 to March 2006, using the observed SST as boundary condition.

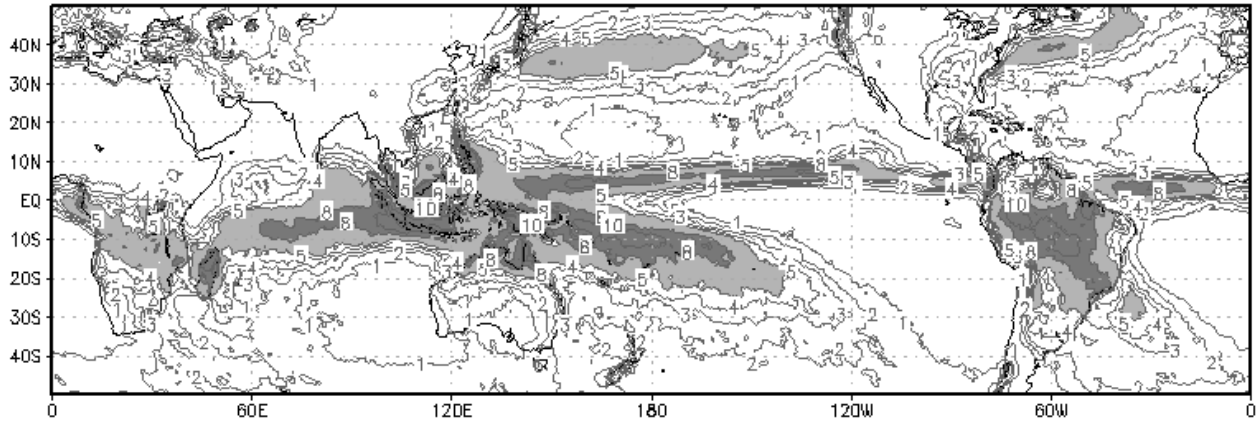
- RESULTS: ensemble For DJF

LONG INTEGRATIONS 1981-2009 (29 years)

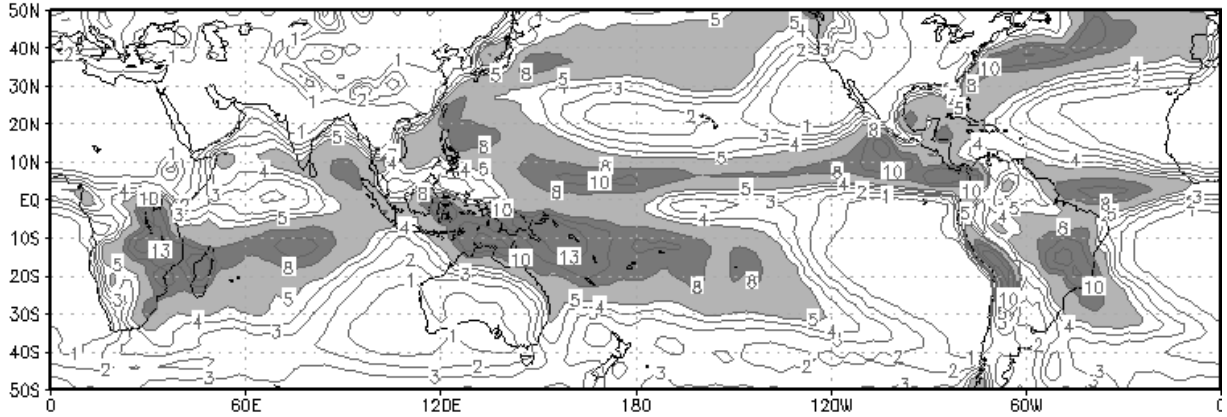
1. The new atmospheric model have been run for different initial conditions from September 1981 to March 2009, using the observed SST as boundary condition.
2. The NCEP/NCAR reanalysis and TRMM data were used for comparison.

Results: Summer SAMS for 1981-2010

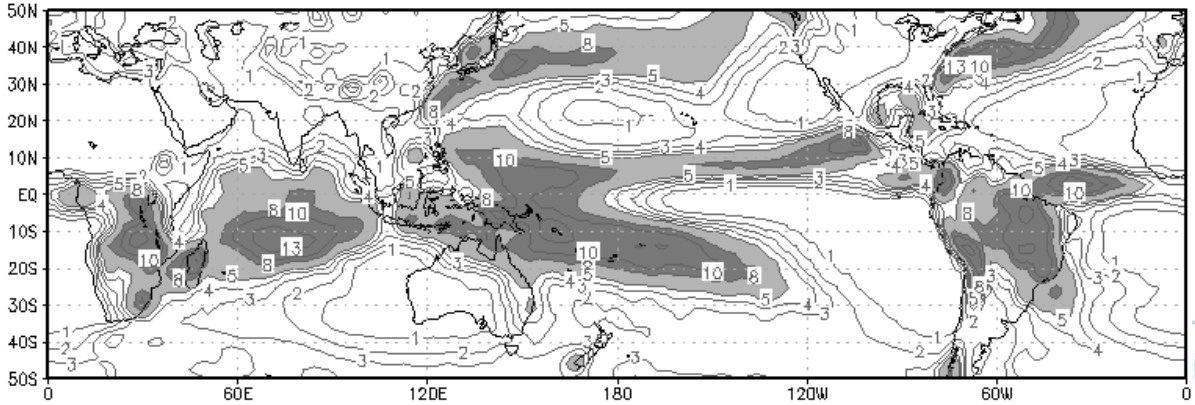
TRMM - 1998-2009



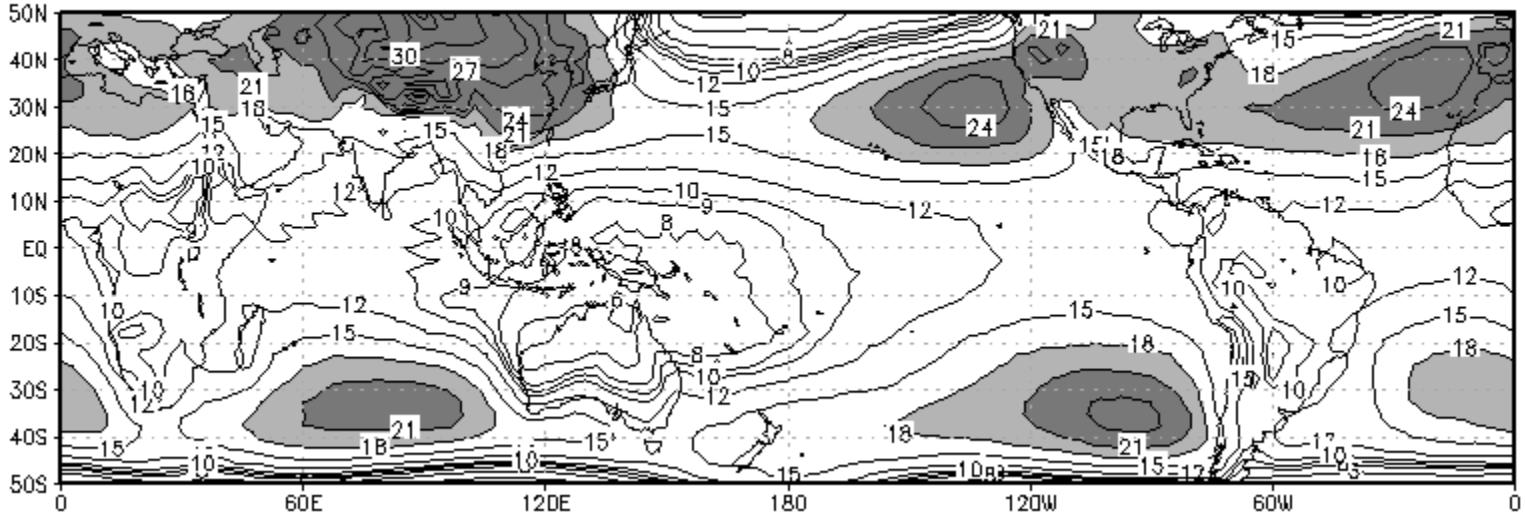
AGCM1-CPTEC - 1998-2009



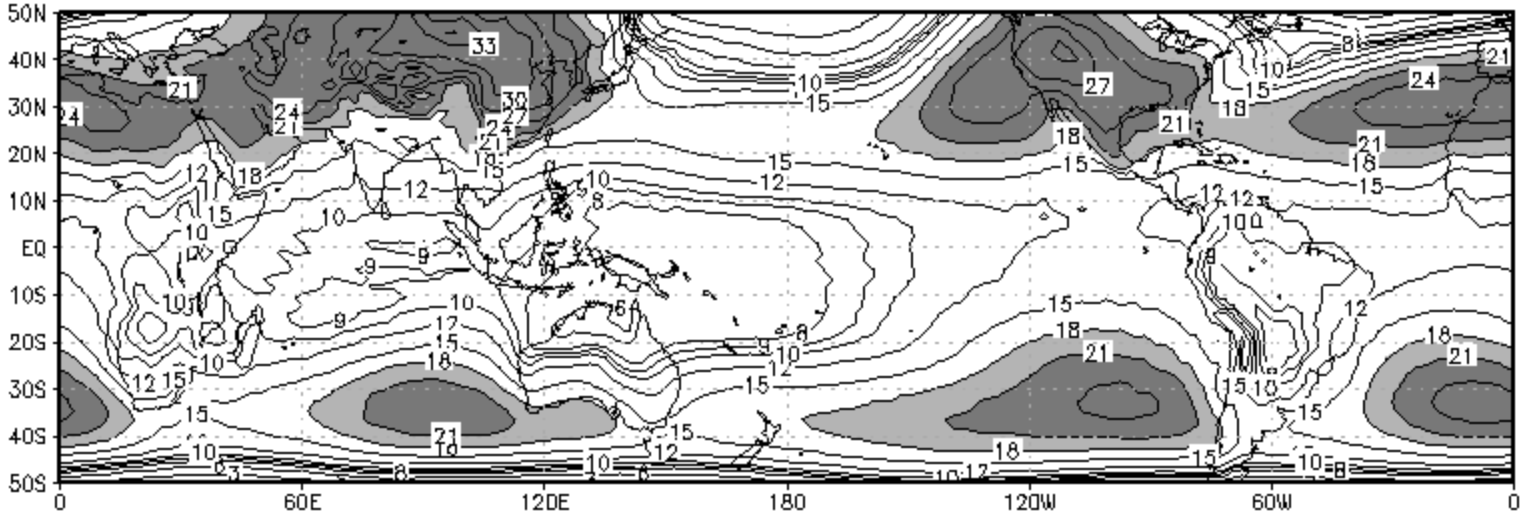
AGCM2-CPTEC - 1998-2009



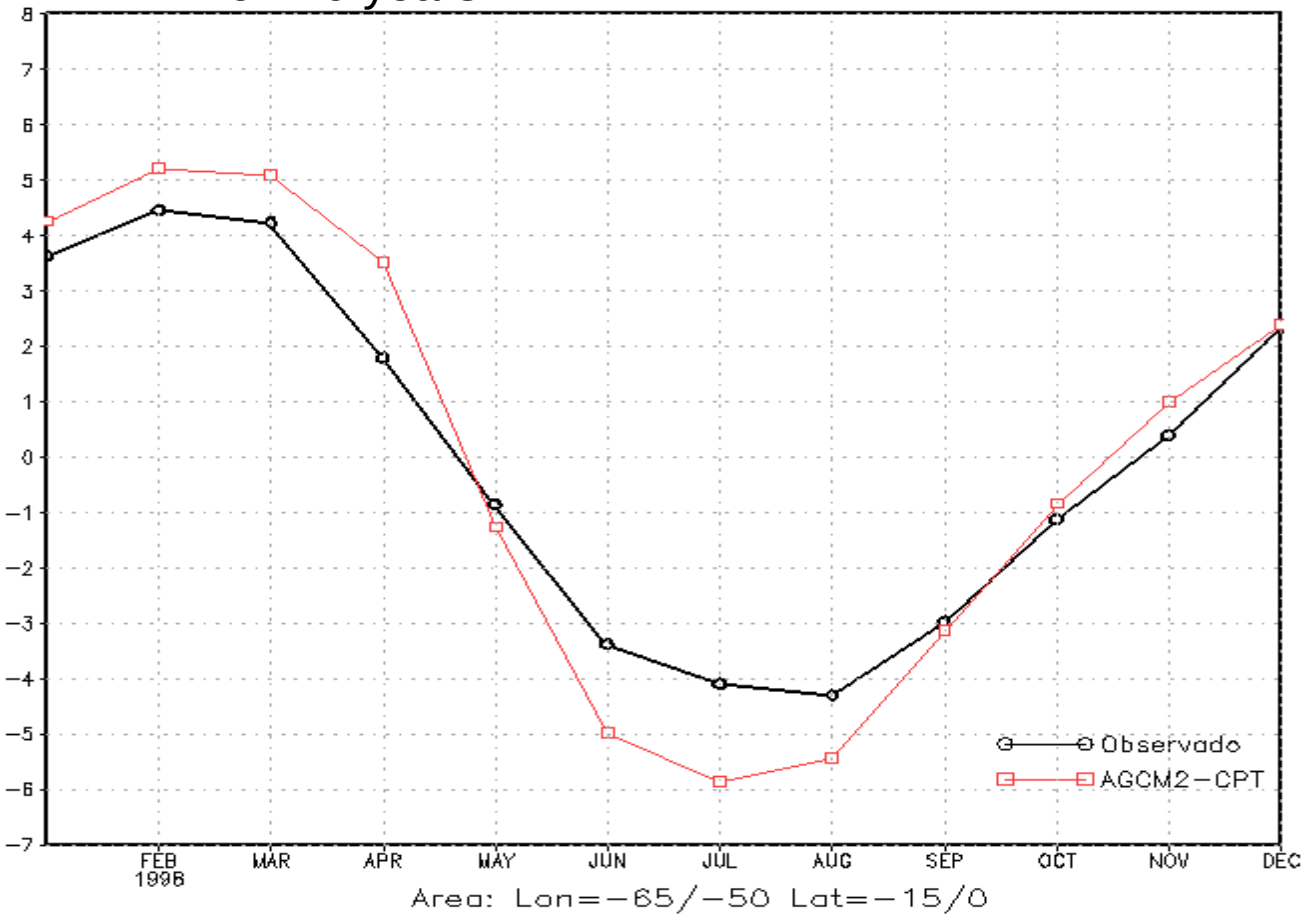
NCEP – 1998–2009



AGCM2 – 1998–2009



Annual Cycle of Precipitation
For 29 years



Preliminary Conclusions

1. The transition from shallow to deep convection is very complex process, however it is the most important process on the land to simulate the diurnal cycle of precipitation.
2. A little improvement of diurnal cycle of precipitation improve the heating profile in lower troposphere around 700 hPa.
3. The CPTEC-AGCM2 (with new convection schemes) simulate more realistic the South American Monsoon System, such as:

a) a intense precipitation over central Amazon and Central Brazil during the summer,

b) the extension of Amazon precipitation into South Atlantic Convergence Zone (SCAZ),

c) the upper and low-level circulation associated with the South American Summer Monsoon System (Bolivian High and Chaco Low).

However, the maritime component of the SACZ is underestimated.

Some Issues

- How can the convective and stratiform precipitations be defined accurately from observations and models?
- What are the dominant mechanisms responsible for the diurnal cycle of clouds and precipitation?
- SP can resolve the diurnal cycle of precipitation in global models ?

CPTEC
Centro de Previsão de Tempo e Estudos Climáticos

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Thank You

WWW.CPTEC.INPE.BR